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FOR IMMEDIATE RELEASE

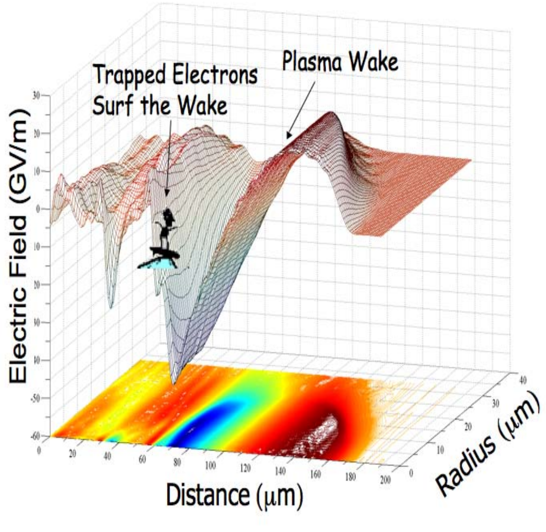
Electrons Surf Plasma Waves to Record-High Energies

Plasma wakefield accelerator doubles electron energy in just one meter.

ORLANDO, Florida—Particle accelerators allow scientists to probe the building blocks of the universe and its initial conditions. They are also some of the largest and most complex scientific instruments ever built, and future radiofrequency-based linear accelerators will be tens of kilometers long. A promising new technology, the plasma wakefield accelerator (PWFA), capable of accelerating particles to very high energies over very short distances could one day revolutionize the world of high-energy particle physics.

In a PWFA, a short charged particle bunch travels in neutral plasma, creating a large plasma amplitude wave, or wake, that has strong focusing and accelerating fields. Thanks to a focusing field more than a thousand times stronger than those of magnets, the beam can propagate and remain compact much longer than it would in a vacuum. At the same time, the accelerating field is more than two hundred times larger than in the radiofrequency cavities of a linear accelerator. The combination of these two fields can lead to very large energy gains over very short plasma distances. In the PWFA, the particles at the head of the bunch drive the wake and therefore lose energy. The particles in the back of the bunch surf on the large electric field and gain energy.

Plasma-based accelerators have made remarkable progress in the recent years. In particular, a collaboration of scientists from the Stanford Linear Accelerator Center (SLAC), the University of California Los Angeles (UCLA), and the University of Southern California (USC) have demonstrated for the first time that the energy of the SLAC collider particles can be doubled in a plasma less than one meter long. For comparison, the SLAC accelerator needs about three kilometers (two miles) to accelerate the incoming electrons to 42 GeV (billion electron volts). This distance is about three thousand time longer than the plasma length over which the same energy gain (42 to 84 GeV) was measured using the plasma wakefield accelerator!



The electrons surf the plasma wake driven by the electron bunch. Simulation by E. Oz, USC.

In addition, the scientists discovered that electrons from the plasma can be trapped in the wake and exit the plasma in a bunch with remarkable properties. The energy of the bunch exceeds 10 GeV and has a finite energy spectrum, its length is in the femtosecond (10^{-15} second) range, and its current and brightness exceed those of the SLAC incoming beam, one of the brightest in the world. Beam brightness reflects the number of electrons that are packed in a small volume of space and velocities. High-brightness beams are an essential requirement for advanced radiation sources such as X-ray free-electron lasers, where PWFA could find other applications.

This collaboration is now preparing the next experiments, which will focus on demonstrating the acceleration of an electron bunch with a narrow energy spread. This will be accomplished by splitting the incoming bunch into a drive bunch that will only lose energy to the wake, and a witness bunch that will only gain energy and exit the plasma with a high quality. At the same time the collaboration is gearing up to demonstrate the acceleration of positrons (the electron's anti-particle) to high energies in plasma. Linear accelerators collide electrons with positrons, and a PWFA energy doubler, or plasma afterburner, could one day contribute to the miniaturization of future linear colliders.

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A brightness transformer using a beam driven plasma wake field accelerator

Invited Session QI2: Intense Beams and Accelerators

4:30 PM–5:00 PM, Wednesday, November 14, 2007
Rosen Centre Hotel - Salon 3/4